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環境省

Ministry of the Environment

# Air Pollution Control Technology In Fertilizer Manufacturing Industry

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Overseas Environmental Cooperation Center, Japan

# **Air Pollution Control Technology in Fertilizer Manufacturing Industry**

## **Committee Members**

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***Urea Plant in Bangladesh***



# 1. Air Pollution in Fertilizer Plant

## Fertilizer

## Raw materials

Nitrogenous F. : ammonia, Chilean saltpeter, limestone +  $N_2$ , ····  
Phosphate F. : phosphate rock  
Potassium F. : ore (ingredient ; KCl + NaCl), KCl, ····  
Coated F. : N, P, K + **thermo plasticity resin**

## Pollutants

## Origins of Pollutants

Soot  
SO<sub>x</sub>  
NO<sub>x</sub>



Boiler, Dryer, Calcining furnace, etc.

Dust

Raw material stock yard, Raw material feed equipment,  
Belt conveyer, Bucket conveyer, Crusher, Mill, Sieve

HF

Phosphate fertilizer plant----- Reactor, Calcining furnace,  
Melting furnace, Phosphoric acid concentration plant

NH<sub>3</sub>

Pelletizer, Dryer

Solvent

Coated fertilizer manufacturing process

## 2. Soot & Dust Collection

### 2-1 Gravitational, Inertial & Centrifugal Dust Collector

#### Stokes' Law

$$V = \frac{g}{18\mu} (\rho_1 - \rho) D^2 \quad (\text{cm/s})$$

V: settling velocity (cm/sec)

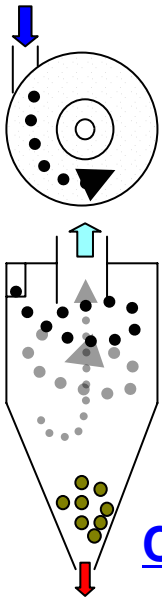
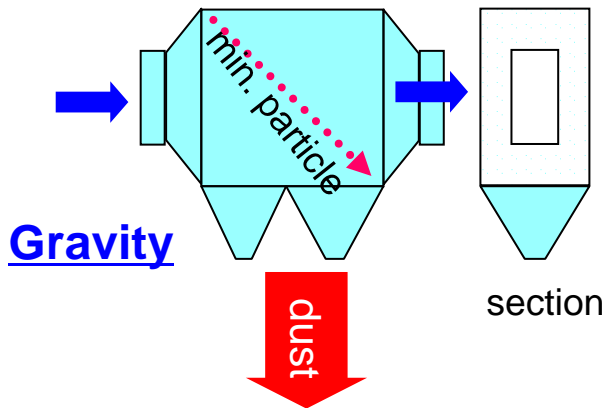
$\mu$ : gas viscosity (kg/ms)

g: gravitational acceleration (cm/s<sup>2</sup>)

$\rho_1$ : particle density (g/cm<sup>3</sup>)

$\rho$ : gas density (g/cm<sup>3</sup>)

D: particle diameter (cm)



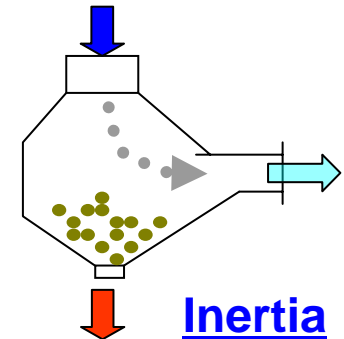
#### Principle of dust collection ;

$$\text{Centrifugal force (F)} = mv^2/R \quad ,(\text{N})$$

m: particle mass (kg)

V: particle velocity (m/ s)

R: cyclone radius (m)



## 2. Soot & Dust Collection

### 2-2 Scrubbing Dust Collector

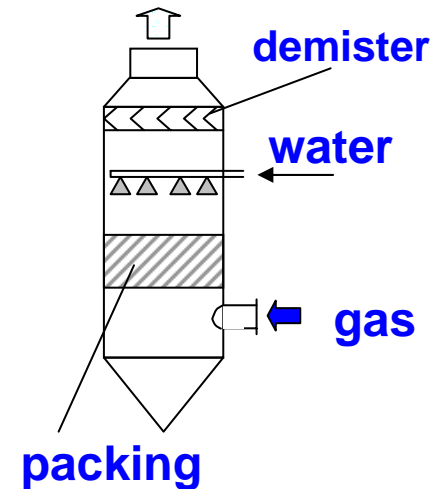
#### Mechanisms of Separation

- Adhesion of dust to water drops & water film by inertia force
- Adhesion by diffusion force among dusts
- Increase of coagulation force of particles by increasing moisture
- Moisture condensation triggered by dust as a nucleus
- Particle adhesion by bubbles

#### Typical Types of Scrubbers

Type	Velocity m / s	L/G l / m <sup>3</sup>	P kPa	Th. μ m
Spray	1~2	2~3	0.1~0.5	3
Packed	0.5~1	2~3	1~2.5	1
Jet	10~20	10~50	0~ -1.5	0.2
Venturi	60~90	0.3~1.5	3~8	0.1

Th. : Particle size of threshold to allowing 50 % removal

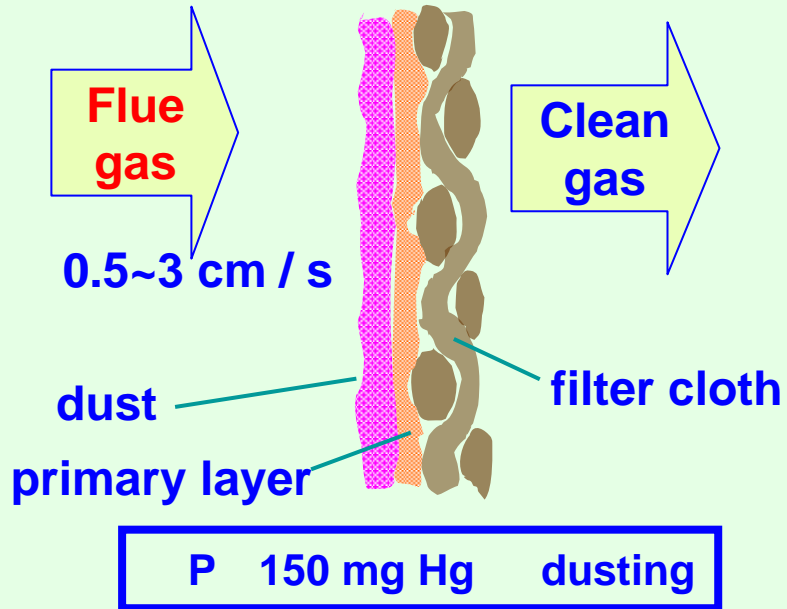


Packed tower

## 2. Soot & Dust Collection

### 2-3 Filter Type Dust Collector

#### Filtration Action in Filter Cloth

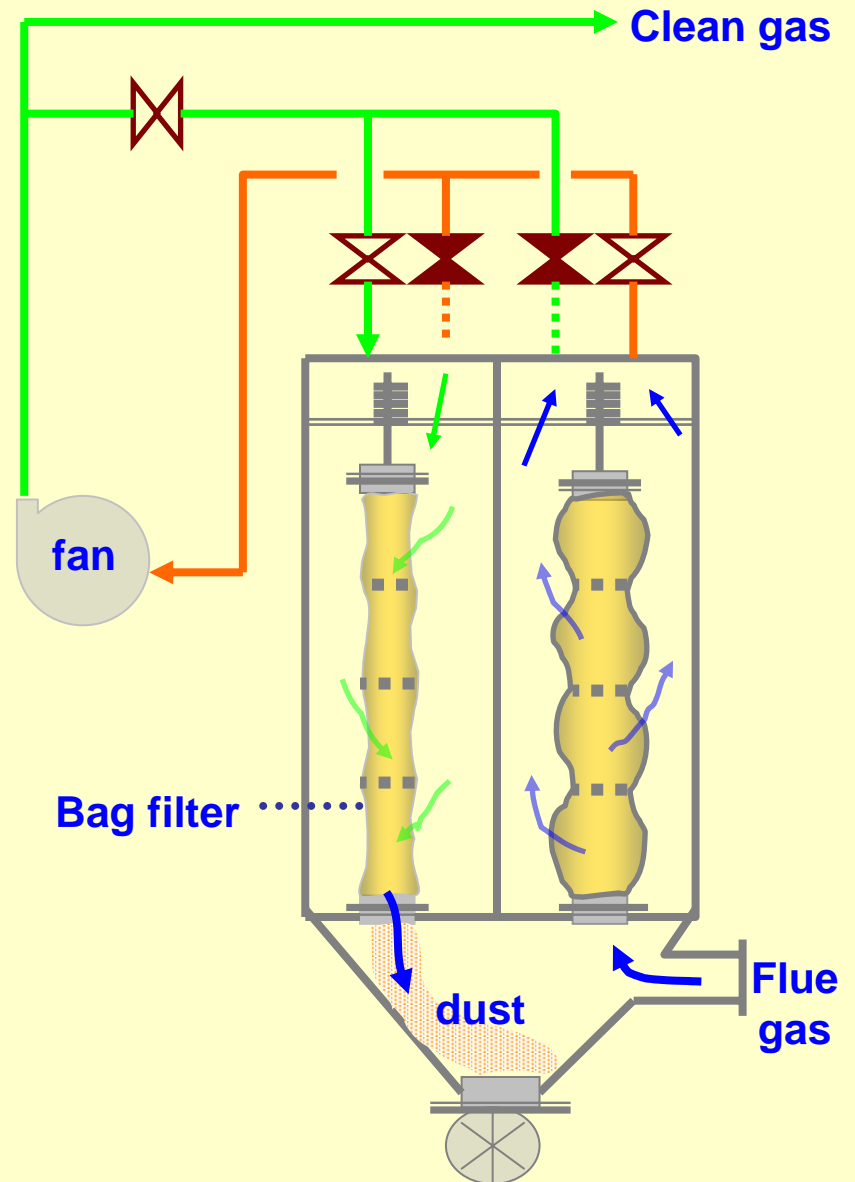


#### Dusting frequency

- intermittent
- continuous

#### Dusting drive

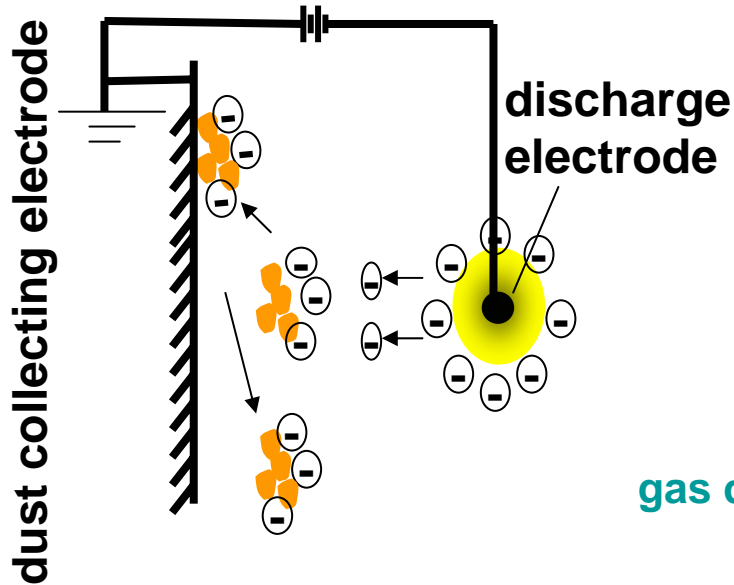
- vibration
- reverse air



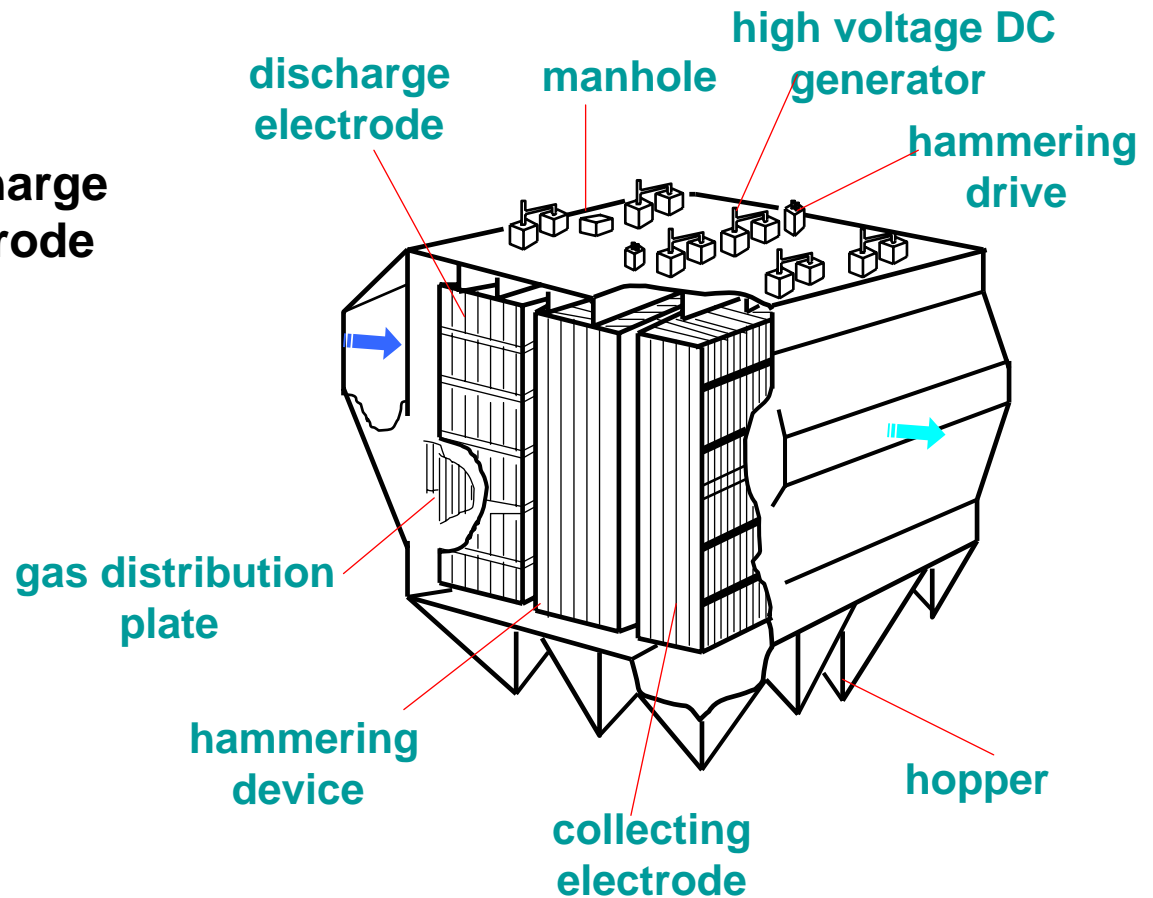
## 2. Soot & Dust Collection

### 2-4 Electrostatic Precipitator

#### Principle of dust collection :



#### Structure of EP





## 2. Soot & Dust Collection

### 2-5 Selection of Dust Collector

#### Factors affecting Dust Collection:

dust concentration, particle size distribution, temperature of dust, apparent electric resistance rate, dew point, gas temperature, composition of flue gas, gas volume, etc.

#### Applicable Range of Dust Collector

Type	Particle ( $\mu\text{m}$ )	Working ( )	Cutback Level (%)	Pressure Drop (mm H <sub>2</sub> O)	Equipment Cost	Running Cost
Gravity	1000~50	d.p. ~ 400	40 ~ 60	10 ~ 15	S	S
Inertia	100~10	d.p. ~ 400	50 ~ 70	30 ~ 70	S	S
Centrifuge	100~3	d.p. ~ 400	85 ~ 95	50 ~ 150	M	M
Scrubbing	100~0.1	no- limit	80 ~ 95	300 ~ 800	M	L
Filtration	20~0.1	no- limit	90 ~ 99	100 ~ 200	M	M
EP	20~0.05	d.p. ~ 400	90 ~ 99.9	10 ~ 20	L	S~M

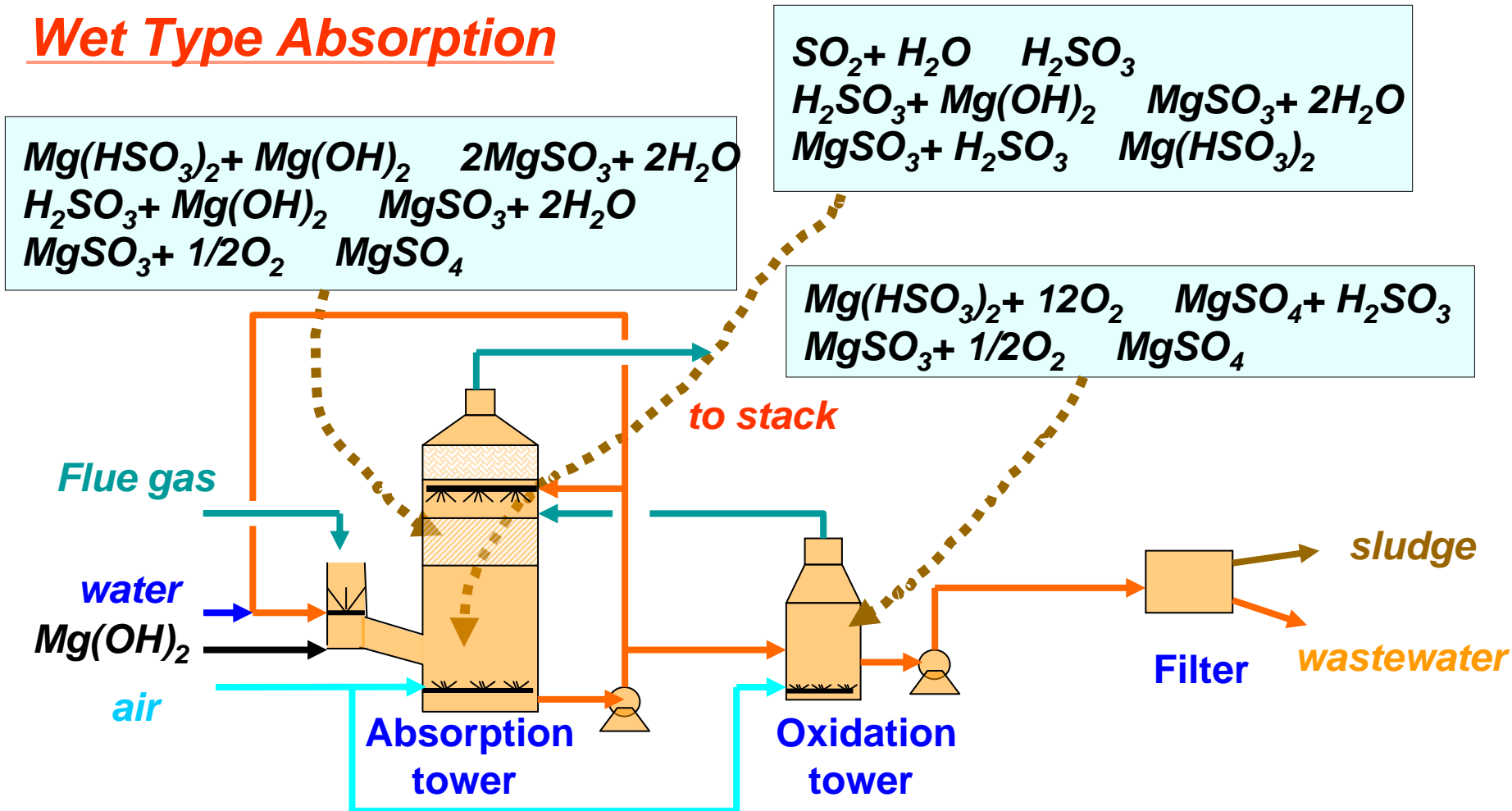
L: expensive M: average S: cheap

### 3. SOx Reduction Technology

#### Sources of SOx: Fuel SOx

- Boiler
- Dryer
- Calcining furnace
- Melting furnace

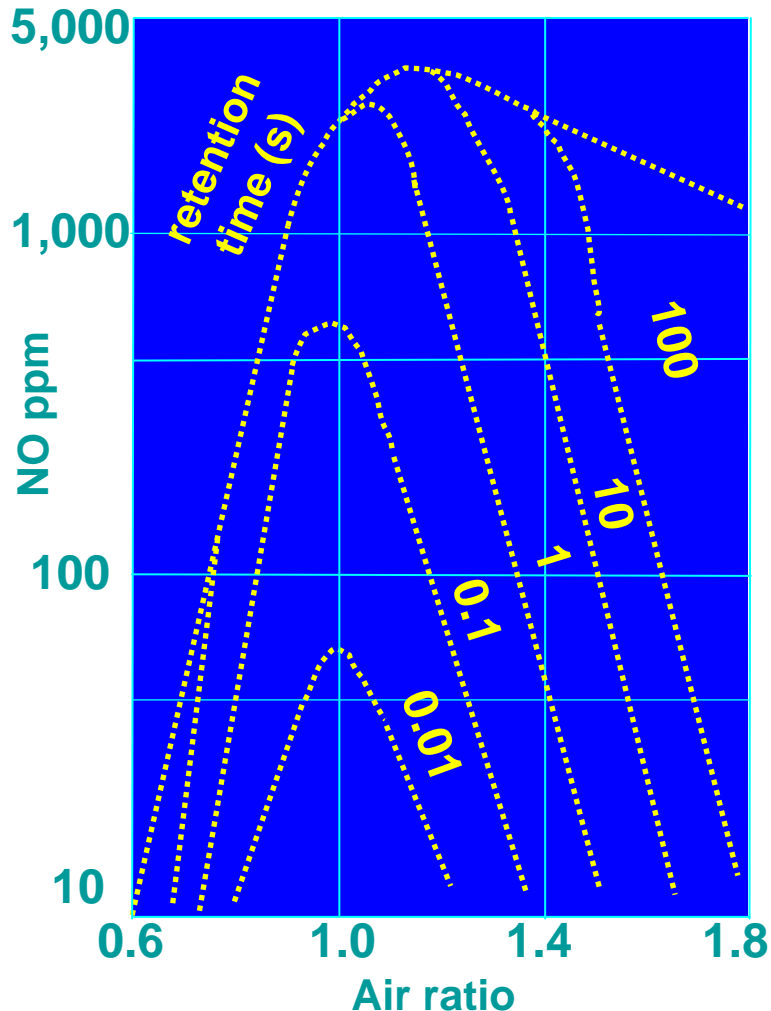
#### Wet Type Absorption



## 4. NOx Reduction Technology

### 4-1 NOx Generation in Fertilizer Plant

Air ratio ~ Retention time ~ Thermal NOx



Thermal NOx      Fuel NOx

NOx concentration increases at:

- higher temp. in combustion
- higher O<sub>2</sub> conc.
- longer retention in high temp. zone

# 4. NOx Reduction Technology

## 4-2 NOx Control Methods

### NOx Reduction Methods

#### Improving operating condition

- Lower air ratio combustion*
- Lower heat load*
- Decreasing pre-heat air temp.*

#### Improving equipment configuration

- 2-stege combustion*
- Rich-lean burner*
- Exhaust gas recirculation*
- Steam or water injection*
- Low NOx burner*
  - mixing accelerate type*
  - flame-divided type*
  - self-circulate type*
  - stepwise combustion type*
- Emulsion combustion*

	Decreasing effect		Remarks				
	Thermal NOx	Fuel NOx	lowering heat efficiency	lowering out put	enlarging equipment	dust increase	
<i>Lower air ratio combustion</i>							
<i>Lower heat load</i>							
<i>Decreasing pre-heat air temp.</i>							
<i>2-stege combustion</i>							
<i>Rich-lean burner</i>							
<i>Exhaust gas recirculation</i>							
<i>Steam or water injection</i>							
<i>Low NOx burner</i>							
<i><u>mixing accelerate type</u></i>							
<i><u>flame-divided type</u></i>							
<i><u>self-circulate type</u></i>							
<i><u>stepwise combustion type</u></i>							
<i>Emulsion combustion</i>							

## 5. Dust Scattering Prevention

### Dust generating equipment & location designated by air pollution control law

- belt conveyer
- bucket conveyer
- crusher, mill
- sieve
- ore stock yard

### Equipment protected work shop environment from dust scattering

- silo, hopper for raw material & product
- transporting equipment except belt & bucket conveyer
- packing machine, etc.

### Measures

- outdoor stock with sheet cover (phosphate rock)

- indoor allocation
- closed cover, negative pressure
- Sealed dust collecting cover
- dust collecting hood

- cyclone
- bag filter

## 6. NH<sub>3</sub> Removal Technology

### 1. Permissible NH<sub>3</sub> emission:

1~ 5 ppm at boundary of premise (set forth by prefecture governors)

$$Q = 0.108 \times H_e^2 \times C_m$$

Q : gas volume (Nm<sup>3</sup> / h)

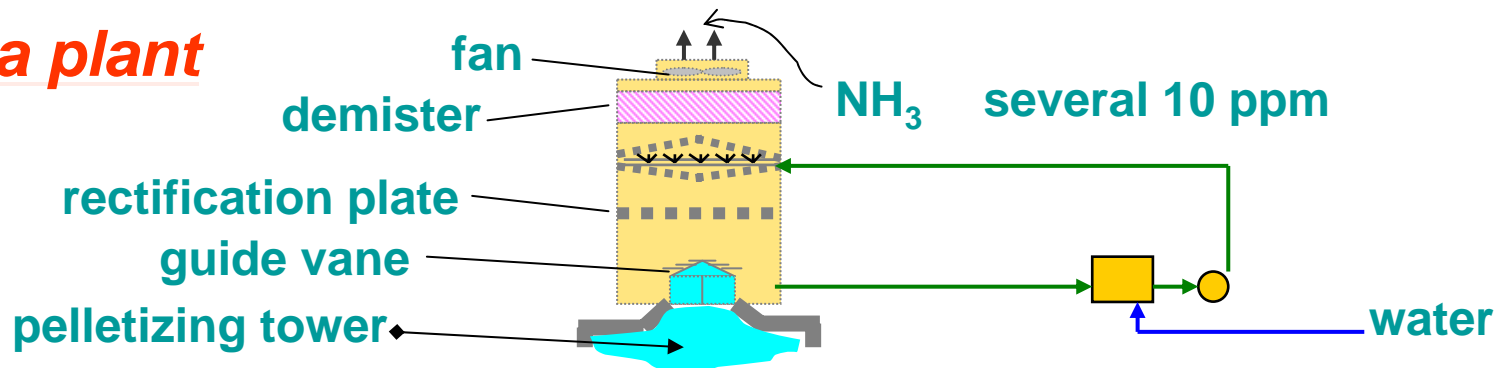
H<sub>e</sub> : effective height of exhausting outlet (m)

C<sub>m</sub>: concentration at boundary line of premise (ppm)

### 2. In compound fertilizer plant :

Process	Origin	Abatement
pelletizer & drying	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> (NH <sub>4</sub> ) <sub>3</sub> PO <sub>4</sub> CO(NH <sub>2</sub> ) <sub>2</sub>	reservoir type wet scrubber pressurized water scrubber packed bed water scrubber (NH <sub>4</sub> removal 70~90%, 20~50ppm)

### 3. In urea plant



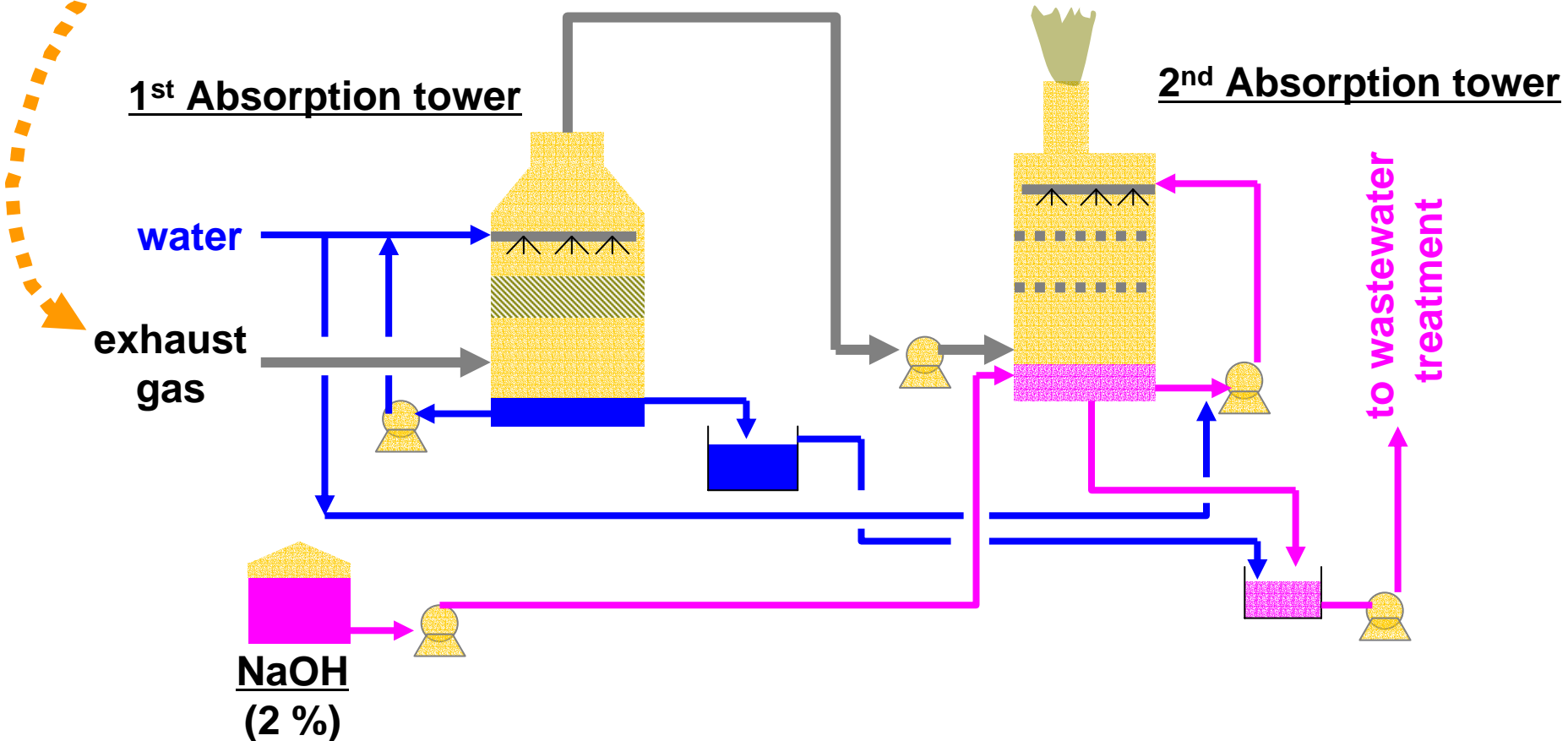
## 7. F Removal Technology

### Generation of F

- reaction & condensation process for  $\text{H}_3\text{PO}_4$  production
- reaction process for  $\text{Ca}(\text{H}_2\text{PO}_4)_2$  production
- reaction furnace for fused P and calcined P production

$\text{HF}$ ,  $\text{SiF}_4$

(with greater hydrophile property)



# 8. Odors Abatement technology

## 8-1 Abatement Processes

### Deodorizing Method

### Process

#### Incineration method

direct incineration  
regenerative thermal oxidizer  
catalytic incineration

decompose to  $CO_2$ ,  $H_2O$  by heat  
at 800  
regeneration, heat efficiency > 80%  
using catalysis at 200~ 350 , rem. > 99%

#### Scrubbing method

scrubbing by chemical solution  
water, acid, alkaline, oxidant, etc.

#### Adsorption method

recovery type  
fixed bed  
fluidized bed  
concentration type  
honeycomb  
replacement type

activated carbon, steam regeneration  
activated c., heat regeneration by  $N_2$  gas  
separating odor from low concentration gas  
replacing saturated adsorbent or oxidant

#### Biological method

soil bed  
packed tower

biodegradation by microorganisms  
using soil bacteria  
using bio-film on the media

#### Deodorizer, masking agent

deodorize or easing offending gas



## 8. Odors Abatement technology

### 8-2 Troubles in Abatement Processes (examples)

#### Deodorizing Method

#### Trigger

#### Trouble

#### Combustion method

direct incineration

regenerative thermal ox.

catalytic incineration

NO<sub>x</sub>

mixture of Cl<sub>2</sub>, paint, etc.

mixture of Cl<sub>2</sub>, paint, S, etc.

permission level

HCl, clogging

catalyst deterioration

#### Adsorption method

recovery type

fixed bed

fluidized bed

concentration type

honeycomb

replacement type

mixture of ketone, high B.P.  
substance

high temp. of exhaust gas

mixture of cyclohexane

conc. > several ppm

firing, deterioration  
of activated carbon

A.C. deterioration

firing

short term A.C.

replacement

#### Biological method

soil bed

packed tower

drying of soil

slow acclimatization

malfunction

slow starter

#### Scrubbing

less sprinkling water

dust in gas

malfunction

clogging internals

## 9. Solvent Recovery & Abatement technology

### 1. Sources of Generation

**coated fertilizer (thermoplasticity resin)**

### 2. Abatement

**recovery of solvent brings profit    production cost reduction  
residual solvent value    recovery cost    pollution control**

### 3. Abatement Process

**- cooling condensation method**

**cool down flue gas below vapor pressure**

**- absorption & dispersion method**

**absorbing of solvent to absorbent with lower vapor pressure**

**- adsorption & dispersion method**

**applicable to compositions with low vapor pressure and non-existence of antagonist. Adsorbed at under pressure or lower temp..**

**adsorber: fixed bed, moving bed, fluidized bed**

**adsorbent: A.C., silica gel, molecular sieve, aluminum gel**

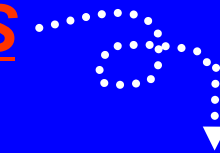
**regeneration method: heated gas, steam, heat transfer,  
extraction under decompression**

## 10. Environmental Management System

### 1. Environmental Management System

- Organization for Environmental Control
- ISO 14000 series----- PDCA cycle
- Responsible for environmental protection

EMS



**ISO 14000**

### 2. Environmental Control Manual

- Operation Standard Manual

### 3. Education & Training

- legally qualified expert of environment control
- training program and preparation of manual

### 4. Environmental Control at Work Shop

### 5. Environment Monitoring

- maintaining monitoring system
- monitoring of air pollution state
- legal emission permissible level